

# Mapping Drug Overdose Demographic and Socioeconomic Characteristics in the Community

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## ABSTRACT

**Introduction:** Drug use and drug overdose have increased at an alarming rate.

**Objective:** To identify demographic and neighborhood social and economic factors associated with higher risk of overdose. These findings can be used to inform development of community programs and appropriately devote resources to prevent and treat drug abuse.

**Methods:** The electronic health records of all patients seen in the emergency department or admitted to the hospital for a drug overdose in 2016 at Gundersen Health System in La Crosse, Wisconsin, were reviewed retrospectively. Patient data collected included age, sex, race/ethnicity, insurance type, overdose intention (intentional, unintentional), drug involved, and total charge for the episode of care. Patient residence was geocode mapped to census tract to analyze the relationship of drug overdose to neighborhood characteristics. Overdose rates were calculated by census tract and compared by several sociodemographic characteristics.

**Results:** Four hundred nineteen patients were included in this study. Forty percent of overdoses were unintentional. Patients who were older, male, nonwhite, and who had no insurance were more likely to have unintentional overdoses. Opiates and heroin were most commonly present in unintentional overdoses, whereas benzodiazepines and sedatives were more common in intentional overdoses. Patients living in census tracts with a higher percentage of residents with some college also had a higher rate of unintentional overdose. Rates of overdose at the census tract level varied and were higher in tracts with lower median income, low income inequality ratio, high percentage of college attendance, and higher percentage of nonwhite residents. The average charge per overdose was \$14,771 (median = \$9,497) and totaled \$6,188,923 for the year.

**Conclusions:** This study provides demographic, geographic, and socioeconomic detail about drug overdose in the community that can be used to focus future treatment and prevention interventions.

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## BACKGROUND

According to the Centers for Disease Control and Prevention, opioid and drug-related overdoses have reached epidemic proportions in the United States, with overdose deaths nearly tripling between 1999 and 2014.<sup>1</sup> From 2000 to 2014, the rate of death from overdose rose 137%, including a 200% increase in the rate of overdose deaths involving opioids.<sup>2</sup> In 2015, more than 52,000 Americans lost their lives from overdose,<sup>3</sup> including 878 Wisconsin residents.<sup>4</sup> In order to combat this alarming trend and save more lives, communities must increase access to antidotes, ensure rapid deployment of emergency medical services, provide preventive policing, and expand programs that educate community and family members. Each community must take an in-depth view of its population to better approach treating and preventing drug overdoses. Using the data from this study, we hope to provide a focused approach toward solving the epidemic across our counties, state, and country.

Gundersen Health System is headquartered in La Crosse, Wisconsin, and serves La Crosse County, which has a population of approximately 120,000,<sup>5</sup> as well as surrounding counties in Western Wisconsin, Northeastern Iowa, and Southeastern Minnesota.<sup>6</sup> Gundersen Lutheran Medical Center is a 325-bed hospital with approximately 14,000 hospital admissions and over 56,600 emergency department (ED) visits in 2016. Over the past 5 years, deidentified summary data regarding overdose-related hospital admissions and ED visits at Gundersen Health System have been shared with the local community's Heroin and

Other Drug Task Force to track opiate and drug use. The health system has experienced a 148% increase in drug-related hospitalizations since 2013.

We set out to better understand the differences between intentional and unintentional overdoses treated by our health system. In order to improve the community's approach to the growing drug abuse problem, we examined how patient-level characteristics (eg, age, sex, race, insurance availability) and population-level characteristics (socioeconomic, educational, and neighborhood) are related to these overdoses so that resources can be allocated properly. When these trends are better understood and addressed at the local community level, the enormous monetary and human toll exacted by drug abuse can be reduced.

## METHODS

Following approval of the study by the Gundersen Clinic, Ltd Human Subjects Committee/Institutional Review Board, we conducted a retrospective review of the electronic health records (EHRs) of all 472 patients seen in the ED or admitted to the hospital at Gundersen Lutheran Medical Center in La Crosse, Wisconsin for overdose in 2016. Patients were identified by querying our EHR system using the *International Classification of Diseases, Tenth Revision (ICD-10)* codes T40, T42-T48, and T50. Patients with "adverse effects of" or "underdosing" as a poisoning type description were excluded. Some validation of results was done by reviewing patients' EHRs to support the exclusion of these poisoning types. Patients under the age of 10 years and older adults with diagnoses for adverse effects of hematological agents or medications for the cardiovascular and gastrointestinal systems also were excluded. These events were deemed incidental and outside the scope of this study. After excluding these incidental overdoses, 419 discrete patients met inclusion criteria. Patients who died before arriving at the hospital were not included in the study because no information was available for them in the EHR system.

We conducted analyses to understand differences in overdose intention (unintentional, intentional) by examining patient-level and population-level data. Data collected at the patient level included age, sex, race/ethnicity, insurance type, drug involved, and total charge for each episode of care. The EHRs of patients whose intentions were initially undetermined were reviewed and intention was coded as *intentional* if there was evidence the patient had intended to harm himself/herself.

Population-level data were based on where the patients resided. In 2016, we began mapping patients' residential locations to census tract using a geographic information system coder. To maintain patient confidentiality, we could neither map patients' exact location of the residence, nor could we assign patients to a more granular level such as census block group or census block. Census tract level data were obtained for

each patient from the American Community Survey (<https://www.census.gov/programs-surveys/acs/>) and included information from 2015 on income (poverty, children in poverty, median household income, income inequality ratio at the 80th and 20th percentiles), education (high school graduation, some college), unemployment rate, and neighborhood/social characteristics (nonwhite population, rental property, and disability). Based on the overall distribution of the sociodemographic characteristics in the 142 census tracts in the health system's service area, census tracts were categorized as being in the top 25% or bottom 75% of risk for each of these characteristics. We chose to split each census tract variable in this way in part because they were not normally distributed, but also because it allowed us to better compare and contrast high- and low-risk census tracts on a certain characteristic in a fairly homogeneous geographical area.

A second analysis was conducted at the census tract level. Overdose rates (overall, unintentional, and intentional) for each census tract were calculated by dividing the number of overdoses in the census tract by the population of that census tract in 2015 and expressing it as a rate per 100,000. These rates were then compared by the sociodemographic characteristics of the census tracts.

## Statistical Analysis

For the analysis predicting overdose intention, descriptive statistics comparing patient and population characteristics were analyzed using  $\chi^2$  tests or analysis of variance (ANOVA) or nonparametric ANOVA tests for age. A multivariate model was built with logistic regression using backward elimination.<sup>7</sup> To determine whether population predictors would contribute to the overall model, rather than including only those variables significant from the univariate analysis, we forced all the population predictors in the model to start and allowed them to be removed when the *P* value was  $<.10$ . Odds ratios and 95% confidence limits for the final model were calculated.

Census tract overdose (overall, unintentional, and intentional) rates were compared with census tract characteristics based on this 25%/75% distribution split using ANOVA. A multiple regression was conducted with backward elimination of the significant variables from the univariate analysis.<sup>8</sup> Characteristics not significant at the  $P < .10$  level were removed until no additional variables met this criterion. Regression coefficients of the significant variables and their standard error are provided, as well as an  $R^2$ , which indicates the amount of variability in the overdose rates explained by the variables in the model. *P* values of  $<.05$  were considered statistically significant for all comparisons and statistical tests. All analyses were conducted in SAS 9.4 (SAS Institute Inc, Cary, North Carolina).

**Table 1.** Patient and Population Predictors of Overdose Intention

Predictors	Overall N = 419 (%)	Unintentional n = 169 (%)	Intentional n = 250	P value
<b>Patient predictors</b>				
Age group, years				
≤ 24	122 (29.1)	23.8	76.2	.0001
25-49	219 (52.3)	43.4	56.6	
≥ 50	78 (18.6)	57.7	42.3	
Mean (SD), median	35.1 (15.3) 32.6	39.83 (16.5) 35.9	31.92 (13.6) 29.2	.0001
Sex				
Female	257 (61.3)	30.0	70.0	
Male	162 (38.7)	56.8	43.2	.0001
Race/ethnicity				
White	388 (92.6)	39.4	60.6	.1834
Nonwhite	31 (7.4)	51.6	48.4	
Insurance				
Private	239 (57.0)	40.2	59.8	.0362
Government	155 (37.0)	36.8	63.2	
None	25 (6.0)	64.0	36.0	
Drug type				
Benzodiazepine-based	84 (20.1)	28.6	71.4	.0140
Opiates and related narcotics	54 (12.9)	75.9	24.1	.0001
Heroin	47 (11.2)	85.1	14.9	.0001
Sedatives and hypnotics	166 (39.6)	21.1	78.9	.0001
Amphetamines and stimulants	31 (7.4)	45.2	54.8	.5691
<b>Population predictors, census tract averages</b>				
Poverty rate	15.0	14.5	15.3	.4615
Child in poverty rate	18.1	18.4	18.0	.7396
Median income	\$46,333	\$46,353	\$46,320	.9807
Income inequality rate	3.78	3.74	3.81	.1613
No high school degree	8.7	8.8	8.7	.6533
Some college	61.5	61.0	61.8	.4757
Unemployment rate	4.6	4.6	4.7	.6211
Nonwhite	10.1	10.1	10.1	.9426
Renters	34.0	34.0	34.0	.9726
Disabled	11.7	11.7	11.7	.8931

Abbreviation: SD, standard deviation.

**RESULTS**

Patient- and population-level predictors overall and by overdose intention are shown in Table 1. Patients seen for unintentional overdoses were older and more likely to be men. Nonwhite patients and those with no health insurance also were more likely to have an unintentional overdose. The most common drugs for unintentional overdoses were opiates and heroin, whereas the most common drugs for intentional overdoses were benzodiazepines or sedatives and hypnotics. None of the patients' population-level predictors varied significantly by overdose intention.

Only 3 patients treated for an overdose died during their stay. The mean and median charges per overdose were \$14,771 and \$9,497, respectively, and the total charge for this single episode of care for all 419 patients who overdosed in 2016 was \$6,188,923. Total charge varied by overdose intent: unintentional overdose charges averaged \$9,795 (median \$3,213), whereas intentional overdoses charges averaged \$17,992 (median \$12,756), probably a reflection of the higher rate of hospitalization among intentional overdose patients. The median charge was highest among the overdoses for amphetamines (\$14,619), followed by benzodiazepines (\$11,165), and sedatives and hypnotics (\$11,007). Median

charge was lowest for overdoses in which heroin was involved (\$2,442). Total charge to treat all patients in 2016 was highest for sedatives and hypnotics (\$2.7 million) and benzodiazepines (\$1.4 million). Opiate overdoses in 2016 incurred \$720,000 in charges, and heroin incurred \$500,000.

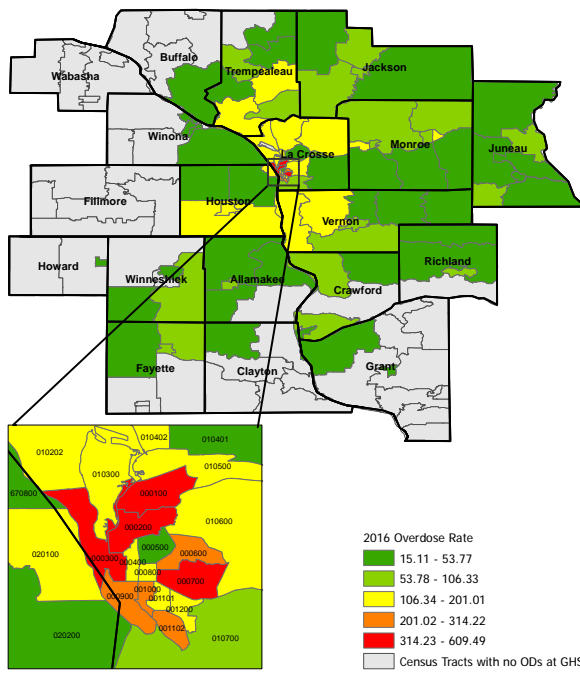
The multivariate model to predict unintentional overdose is shown in Table 2. With every 1 year increase in age, the risk of unintentional overdose increased by 4%. Men were 1.87 times more likely than women to have an unintentional overdose. Nonwhite patients were 2.7 times more likely than white patients to have an unintentional overdose, and those without health insurance were 2.5 times more likely than those with health insurance. Patients admitted with opiate or heroin were much more likely to have unintentional overdoses. Those patients who lived in census tracts with higher college attendance also had higher unintentional overdoses.

Overdose rates by census tract are shown in Figure 1. Unintentional overdose poisoning rates are shown in Figure 2, and intentional overdose poisoning rates are shown in Figure 3.

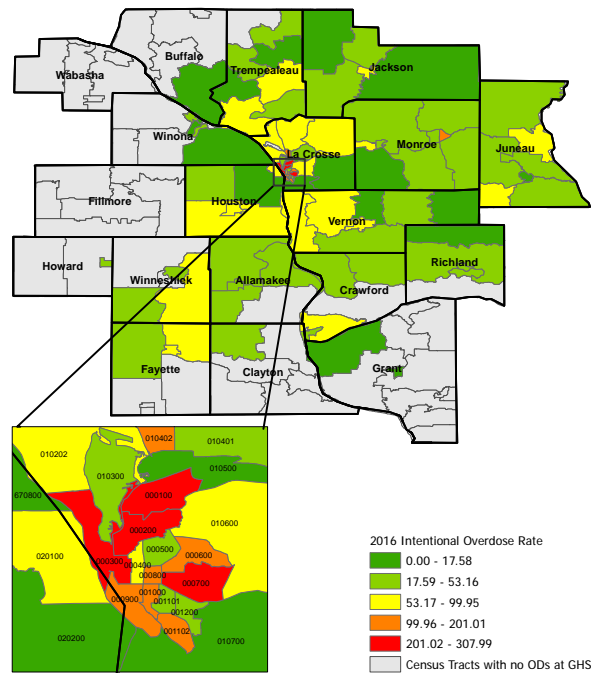
**Table 2.** Multivariate Model of Unintentional Overdose Using Patient and Population Predictors

Predictors	Unintentional : Intentional
<b>Patient predictors</b>	
Age	1.04 (1.02, 1.06)
Sex	
Male	1.87 (1.14, 3.08)
Female	Ref
Race/ethnicity	
White	Ref
Nonwhite	2.69 (1.08, 6.67)
Insurance	
Private	Ref
Government	0.66 (0.39, 1.10)
None	2.53 (0.90, 7.08)
Drug type	
Benzodiazepine-based	0.49 (0.25, 0.98)
Opiates and related narcotics	3.15 (1.36, 7.32)
Heroin	10.34 (3.93, 27.21)
Sedatives and hypnotics	0.39 (0.21, 0.73)
<b>Population predictors</b>	
% some college	1.89 (1.01, 3.56)

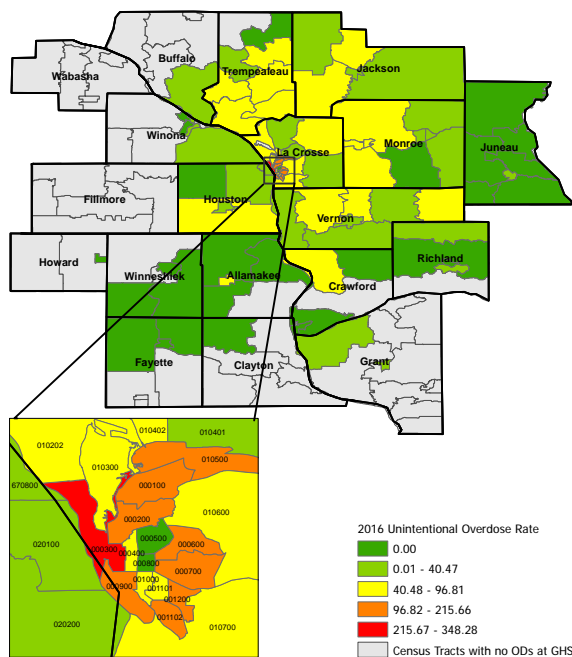
**Figure 1. 2016 Overdose Poisoning Rate by Census Tract for Patients Treated at Gundersen Health System**



**Figure 3. 2016 Intentional Overdose Poisoning Rate by Census Tract for Patients Treated at Gundersen Health System**



**Figure 2. 2016 Unintentional Overdose Poisoning Rate by Census Tract for Patients Treated at Gundersen Health System**



Census tracts within La Crosse County, the most populous, had a higher overall rate and a higher intentional rate of overdose poisonings than those in other counties in the health system service area. Unintentional overdose rates, most of which did not result in

an admission, although high in La Crosse County tracts, also were distributed throughout the rest of the service area. This is probably an underestimate of unintentional overdoses, since many of the unintentional overdoses occurring in the service area were probably treated at regional emergency departments.

Census tract overdose rates were compared by neighborhood social factors (Table 3). The best predictors of high overdose rates overall were low median income, low income inequality ratio, high percentage of some college, and high percentage of nonwhite population. The best predictors of unintentional overdose rates were low income inequality ratio and high rate of rental property. The best predictors of intentional overdose rates were low median income, low income inequality ratio, high percentage of some college, and high percentage of nonwhite population. Overall, these models predicted between 18% and 27% of the variability in overdose rates at the census tract level.

## DISCUSSION

An examination of ED visits and hospitalizations at Gundersen Health System for drug overdoses gives important information in the approach to combating drug abuse in the community. In Wisconsin, the age-adjusted rate of drug overdose deaths has risen significantly from 2010 to 2015.<sup>1</sup> To reverse this trend, better understanding of the issue within the local community is critical.

Our study showed that a majority of patients had private insurance versus Medicaid/Medicare or no insurance. This is contrary to findings in research of the United States as a whole,<sup>9-12</sup> so it



**Table 3.** Multivariate Predictors of Census Tract Overdose Rates per 100,000

Predictors	Overall	Unintentional	Intentional
	Parameter (SEM)	Parameter (SEM)	Parameter (SEM)
Intercept	101.02 (14.82)	38.99 (7.04)	56.71 (8.82)
Poverty risk	-	-	-
Children in poverty risk	-	-	-
Median income risk	61.92 (23.23)	-	41.01 (13.82)
Income inequality risk	-74.80 (23.37)	-38.2 (12.14)	-30.77 (13.90)
No high school diploma risk	-	-	-
No college risk	-72.10 (23.36)	-	-50.46 (13.89)
Unemployment risk	-	-	-
Nonwhite risk	52.83 (21.77)	-	30.42 (12.95)
Rental property risk	-	36.55 (11.21)	-
Disability risk	-	-	-
Final model R <sup>2</sup>	0.2660	0.2730	0.1834

Abbreviation: SEM, standard error of the mean.

may be an important aspect to recognize in the region. Patients living outside La Crosse County were slightly more likely to be insured than those living in La Crosse County, which is consistent with the fact that many of these patients are transferred from other facilities for the primary purpose of admission to the hospital. This process contributed to the higher rate of admission from outside counties (68%) compared with La Crosse County (32%). Sixty-eight percent of unintentional overdoses were treated in the ED without admission to the hospital, which likely reflects the ability to reverse heroin overdose with naloxone and discharge patients without hospital treatment or admission. Opiates and related narcotics accounted for 24% of unintentional overdoses and were found to be consistent across counties. In previous studies, more rural and more impoverished counties tended to have higher prescription drug overdose death rates.<sup>13</sup> Although Gundersen's service area is largely rural, this study's sample size was not sufficiently large to illustrate this trend.

It should be noted that women accounted for 61% of our study population, which is consistent with previous studies,<sup>10,14</sup> but they disproportionately represented 72% of intentional overdoses. Conversely, men represented 39% of the study population yet accounted for 55% of unintentional overdoses. Consistent with all opiate overdoses, 70% of heroin overdoses in 2016 were in men. This is consistent with previous studies in which rates of heroin initiation were highest among men.<sup>14,15</sup>

The overdose epidemic should be viewed through the lens of community impact. Not only are lives being affected by this problem in our counties, but the resource allocation is significant. The charge for unintentional overdoses averaged \$9,795, while intentional overdoses averaged \$17,992. The discrepancy is mainly due to the larger number of intentional overdoses admitted to the hospital and the follow-up care involving Behavioral Health. The 419 patients in this study accrued \$6,188,923 in hospital charges in 2016, and this does not include the cost of prehospital care, the allocation of law enforcement resources, and other

costly social service assistance. Overall, charges for drug-related hospitalizations in Wisconsin totaled \$327 million in 2012, an increase of 49% from 2006,<sup>16</sup> and a number that continues to rise. It is prudent to look toward prevention of overdose to minimize the large expenditures that arise from the acute abuse episodes.

Use of a census tract study is a novel way to examine drug abuse issues in the community and is essential in uncovering the most susceptible hot spots. In our study, higher rates of overdose were found in neighborhoods with low median income, low income inequality, higher

percentage of nonwhite residents, higher rates of some college, and a high percentage of rental properties—characteristics common in many La Crosse County census tracts.

Many public health problems correlate lower income, less education, and being nonwhite to higher intensity of the problem. In 1997, Kawachi et al found a higher rate of mortality in populations with a higher income inequality rate, suggesting that income inequality leads to increased mortality via disinvestment in social capital.<sup>14</sup> However, in our study, overdose rates in census tracts with higher rates of the positive social indicators of high rates of some college education and lower income inequality ratios were found to have higher rates of overdose. This was likely due to the higher level of education overall and low variability in these census tracts, and the high rate of intentional overdoses in these census tracts with other behavioral issues, such as depression. This would be an important consideration when developing and targeting interventions, and would be important to examine in future research.

One limitation to this study was that the geo-mapping was done using the patient's documented county of residence, although that county and the location of the overdose may be different. For example, a student at a local university may experience an overdose on campus but have a permanent address outside the service area, which limits accuracy of the data. Future research could mitigate this limitation by incorporating ambulance service data to explore where the risky behavior was occurring.

This study included patients who were treated at only 1 of the 2 health care facilities in the community, thus underrepresenting the overdose poisoning rates per census tract. We do not believe that the demographic and socioeconomic relationships we found would differ if patients from both facilities had been included. The overall service area and referral systems of the second health system are similar to Gundersen's. Patients who do not or cannot state a health care facility preference are randomly transported to one or the other. Preliminary statistics reported to the Heroin and Other Drug Task Force in La Crosse County from the sec-

ond health system indicate that the number and distribution of overdoses are similar to those reported here. Unfortunately, including the other health system's data in this study was not possible. The degree to which unintentional overdoses are managed at other nonaffiliated critical care hospitals in the region and not transported to either La Crosse hospital is unknown; thus, the rate of unintentional overdoses in the service area may be further underestimated.

Deaths reported by the La Crosse County Medical Examiner for 2016 were reported to the Heroin and Other Drug Task Force and were mapped to census tracts in La Crosse County.<sup>17</sup> This information was based on where the death occurred rather than where the person lived; nevertheless, the 25 deaths that occurred in La Crosse County occurred in those census tracts with the highest overdose rates, further corroborating the findings reported here. Unfortunately, this information is not available to us for other counties in our service area.

Another consideration is that heroin overdoses tend to be coded as *unintentional* unless the patient specifically described intent of self-harm. Some may argue that any ingestion of heroin could be regarded as *passively intentional* overdose. Also, the overdoses of many of the patients who have mental illnesses were coded as *unintentional*, although the intent of these overdoses is difficult to determine based upon their mental state. Although the assessment of the impact mental health has on the abuse of drugs was outside the scope of this project, it would be a crucial item to examine in future studies, as both have become more prevalent.

It is possible that our study suffered from low power. Including additional years of data was complicated by the conversion from ICD-9 to ICD-10. Furthermore, we did not begin to geocode map our patients to census tract until 2016. Analysis at the census tract level may not be sufficiently granular, especially in mostly rural counties, to examine the true variability of socioeconomic characteristics or the impact on overdose rates; however, we believe that it is an improvement over examination at the county- or ZIP code-level because census tracts in La Crosse County reflect neighborhoods, where it is more possible to intervene with local solutions.

This study provided an expanded exploration inside our community drug problem. It is the hope that this information may be used to identify and further assess hot spots of drug abuse in order to address the growing overdose problem. According to a Centers for Disease Control and Prevention report, "a multifaceted, collaborative public health and law enforcement approach is urgently needed."<sup>1</sup> With improved comprehension of the concerns within the community, resources can be better utilized to combat the increasing drug epidemic—not only within La Crosse, Wisconsin, and its surrounding counties, but perhaps in similar communities.

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